



Dynamic Real-Time Deformations

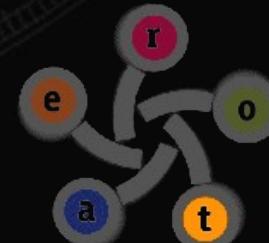
using

Space & Time Adaptive Sampling

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Cani



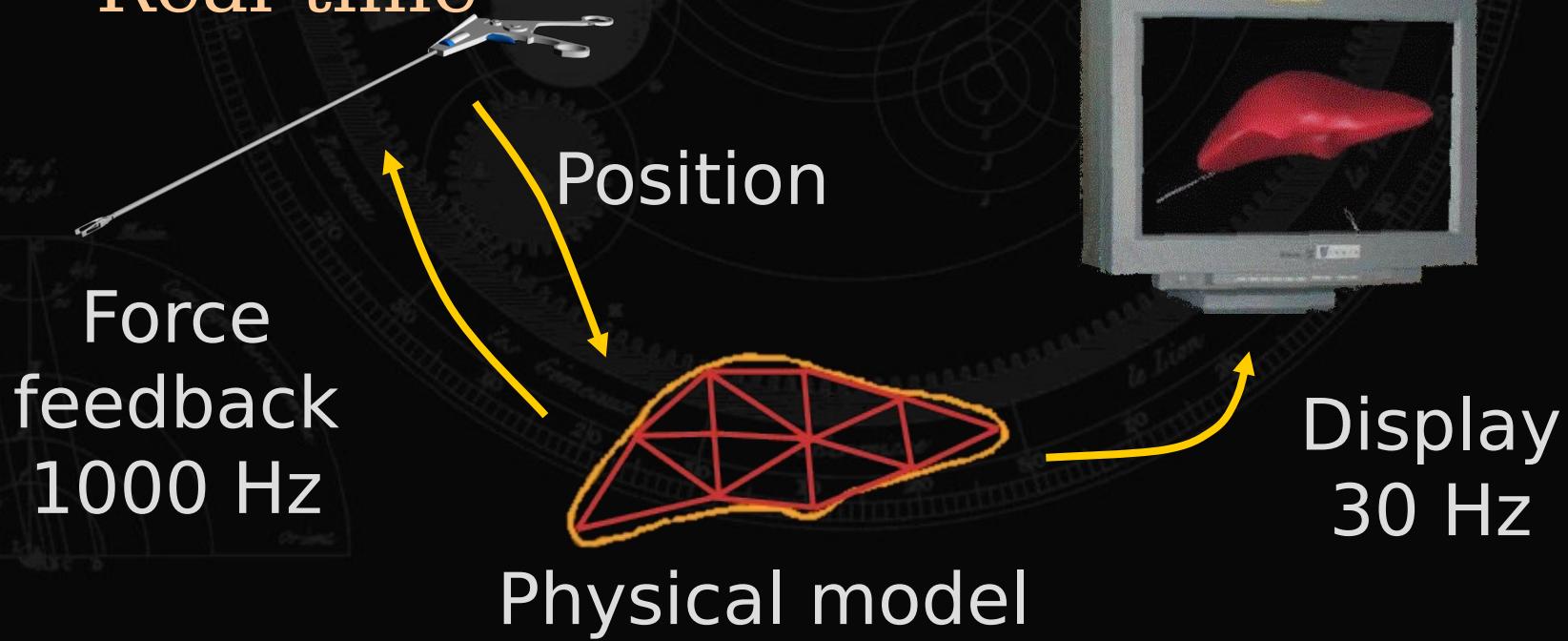
iMAGIS



Goal

Dynamic animation of deformable objects:

- Realistic
- Real-time

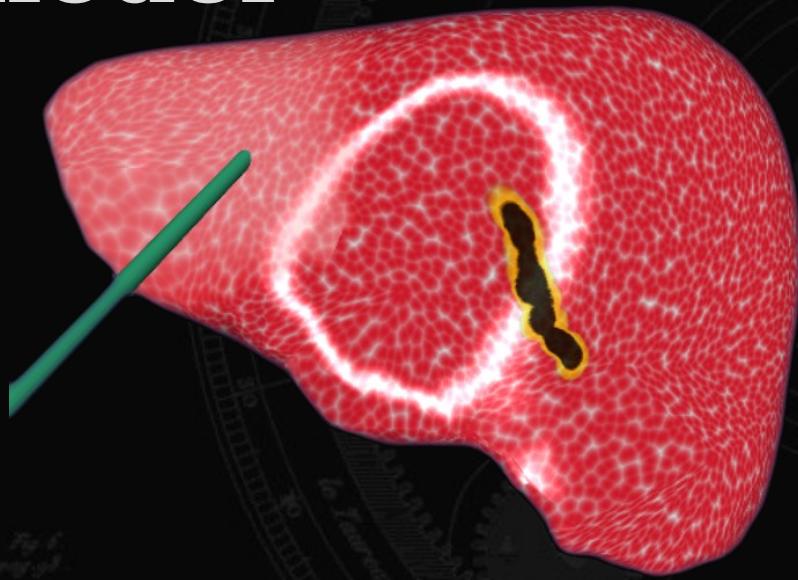


Difficulties

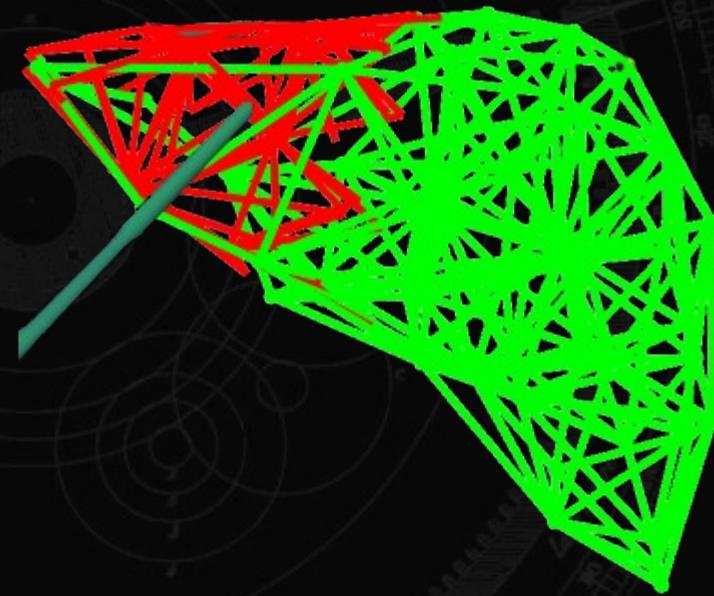
We must combine:

- Visual realism
 - Complex computations
- Haptic feedback, stiff objects
 - Very small time steps (~ 1000 Hz)
- True real-time simulation
 - 1 second of animation computed in 1 second or less

Surface display vs. internal model

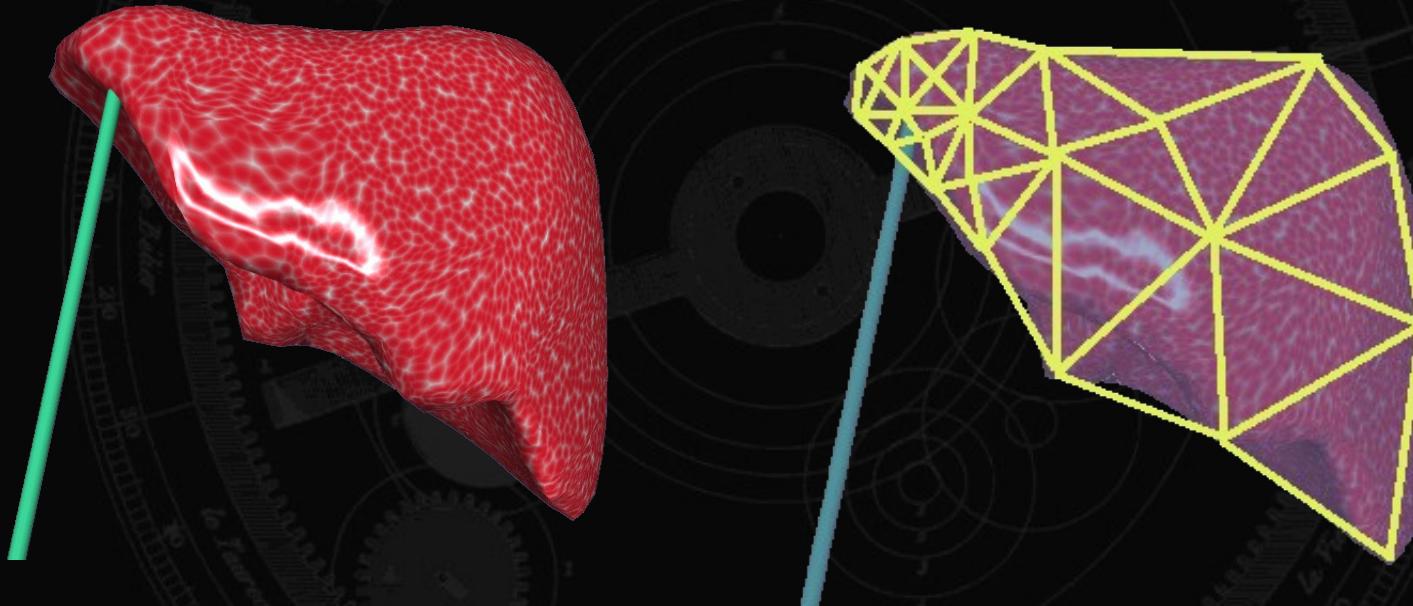


Displayed surface
~10,000 triangles
30 Hz



Internal physical model
~100 points
~1000 Hz

Adaptive sampling



High sampling rate in high deformation
zones

Optimal use of the resources
Reach and ensure real-time

Overview

- Multiresolution animation
- Choice of a physical model
- Results

Previous work

Switch techniques according to visual impact

- Dynamic, cinematic...

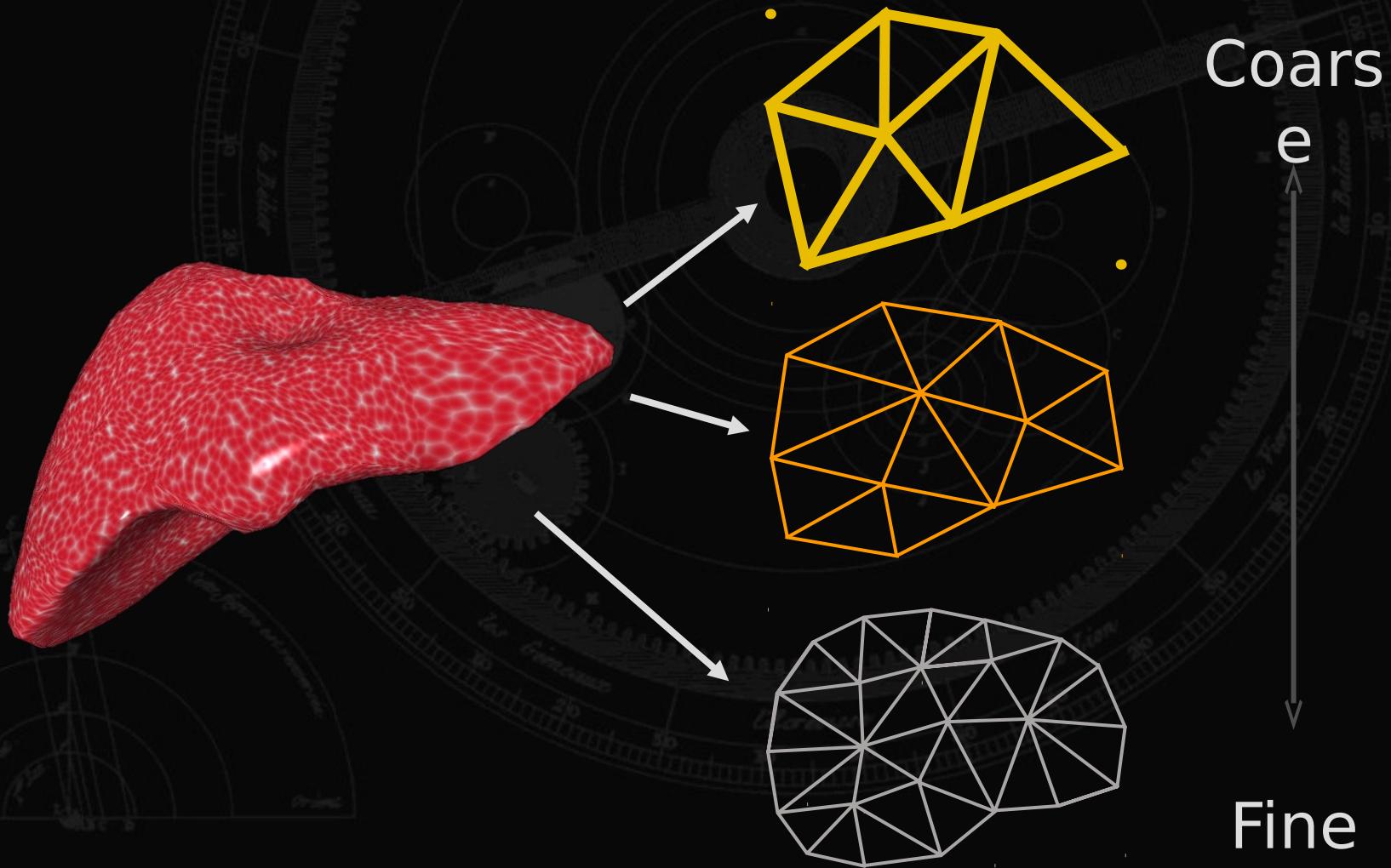
[Berka 97, Chenney & Forsyth 97, Carlson & Hodgins 97]

Adaptive discretization

- Mass-springs [Hutchinson 96, Ganovelli & al 00]
- Finite Elements [O'Brien & Hodgins 99, Zhuang 99]

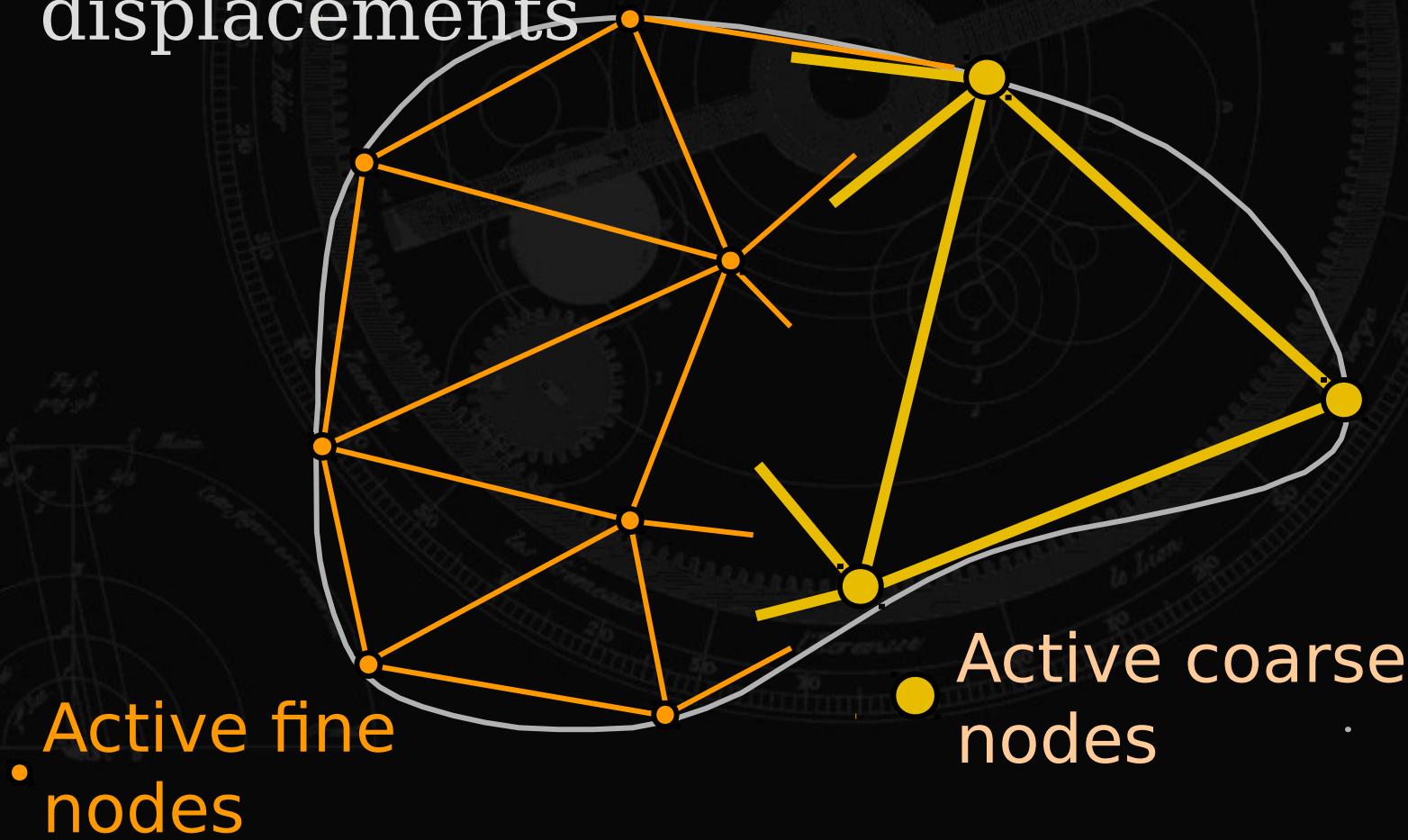
No simplification

Different discretization rates

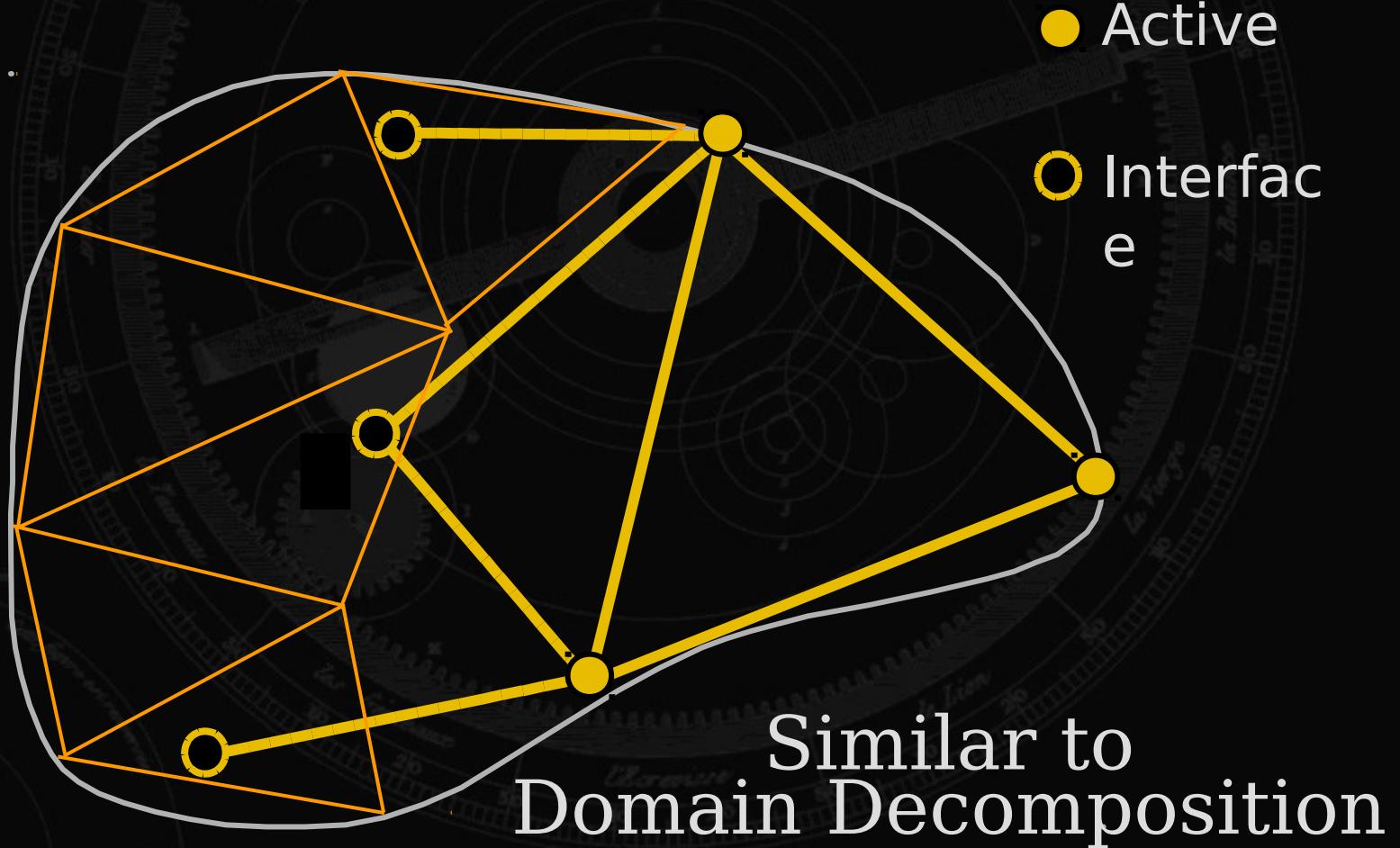


Active nodes

Force computed from neighbors' displacements



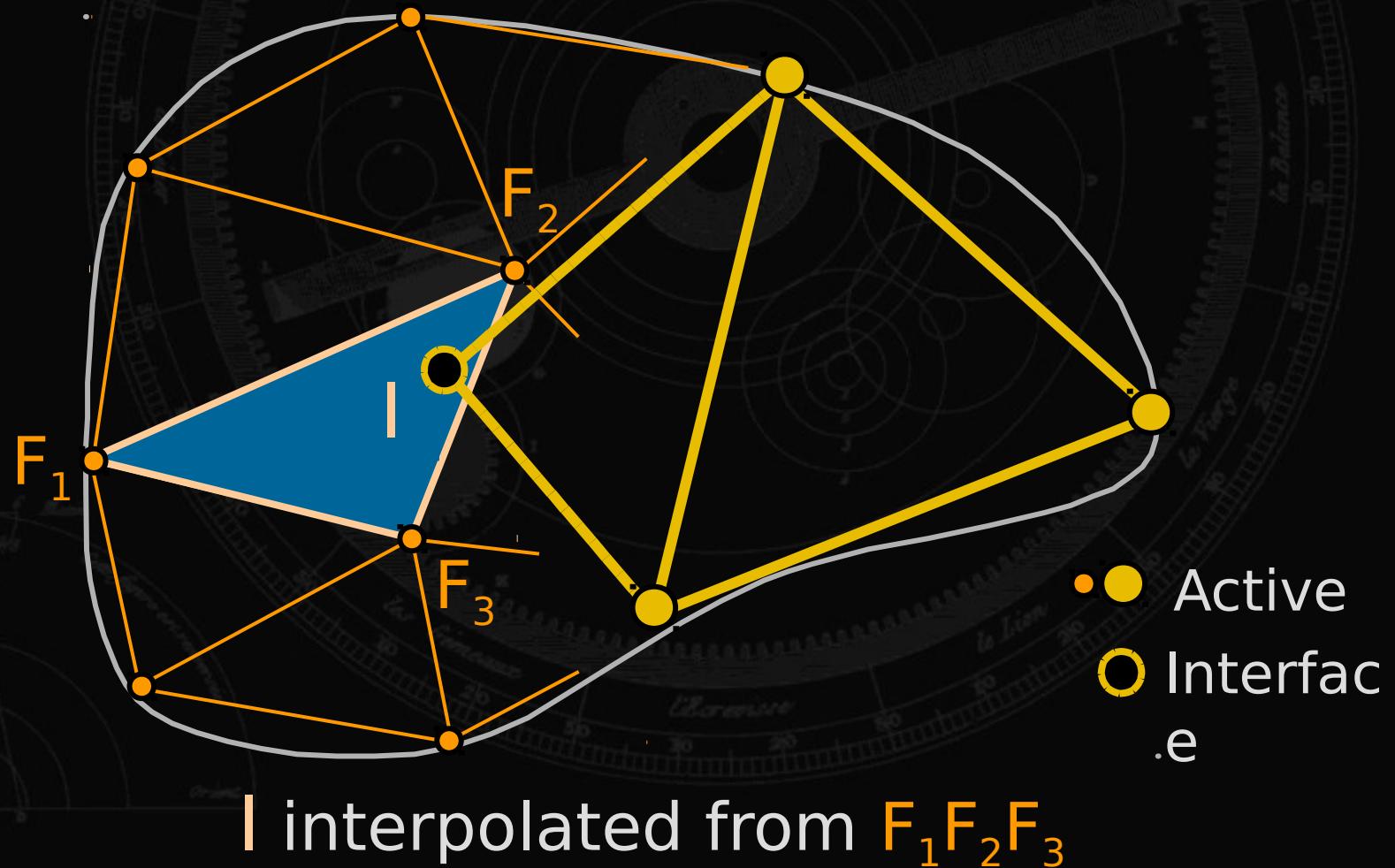
Interface points



Transmitting deformation information

Fine

Coarse



Sampling adaptation

Based on local deformation amplitude

Node replaced by its children in the finer resolution



Children become active



Interface
parent

Active
children

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Goal

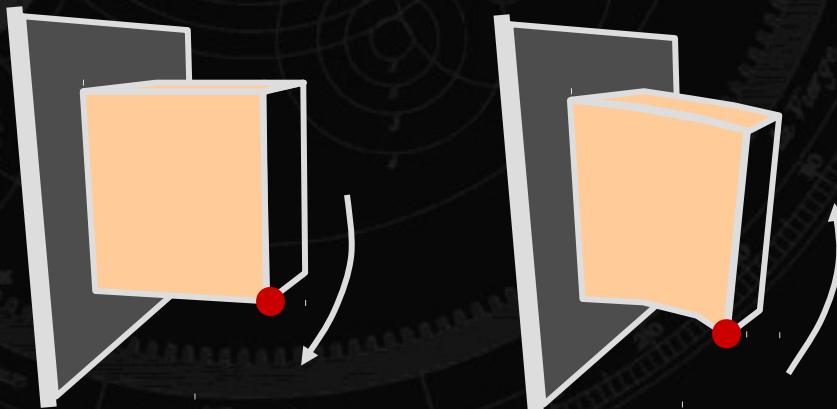
Sampling-independent dynamic simulation

Identical vibration modes

Testbed

No damping

Measure of vertical displacement over



Particle systems

Mass-springs systems
[Hutch96, BW98, GCS00]



Continuous models

Discretization of a continuous equation

- Stress and strain tensors (Cauchy, Green)

Finite Elements [TW88, GMTT89,
BNC96, JP99]

Explicit Finite Elements [Cot97,
OH99]

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Continuous models

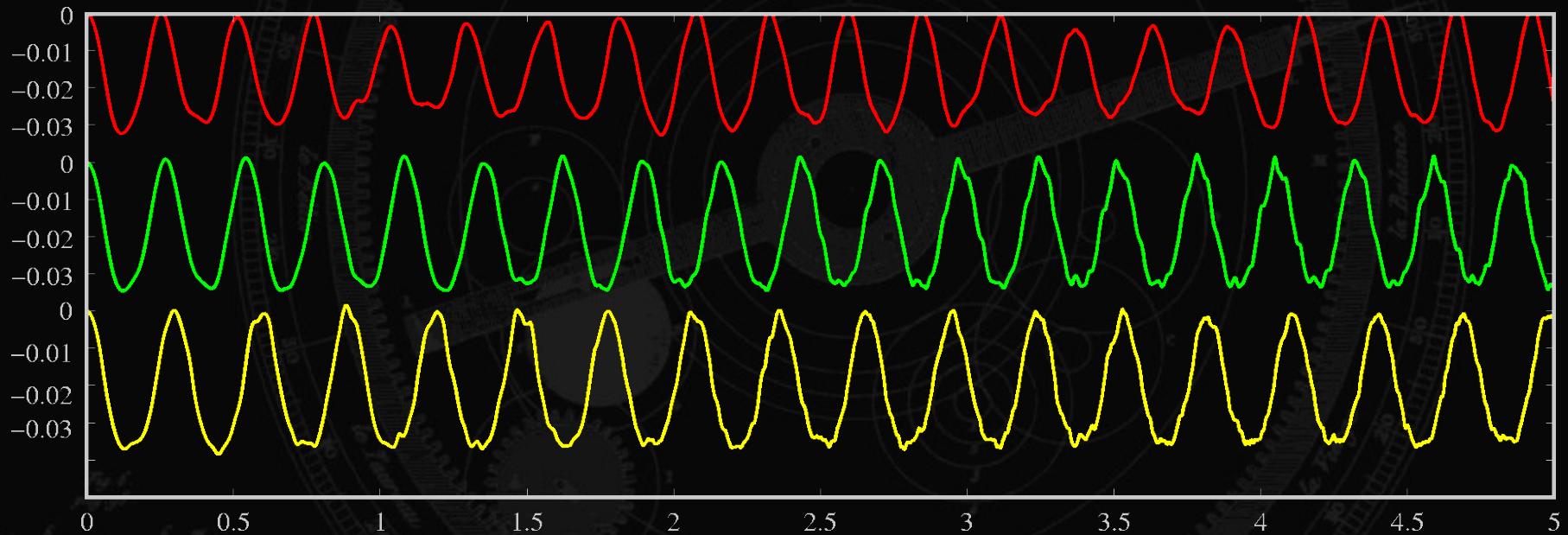
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Green tensor [OH99]



Multiresolution !
(Behaves almost independently of the
resolution)

Multiresolution in time

Courant criterion (CFL)

- Depending on material's stiffness, sampling

Stability

- When force integration may diverge

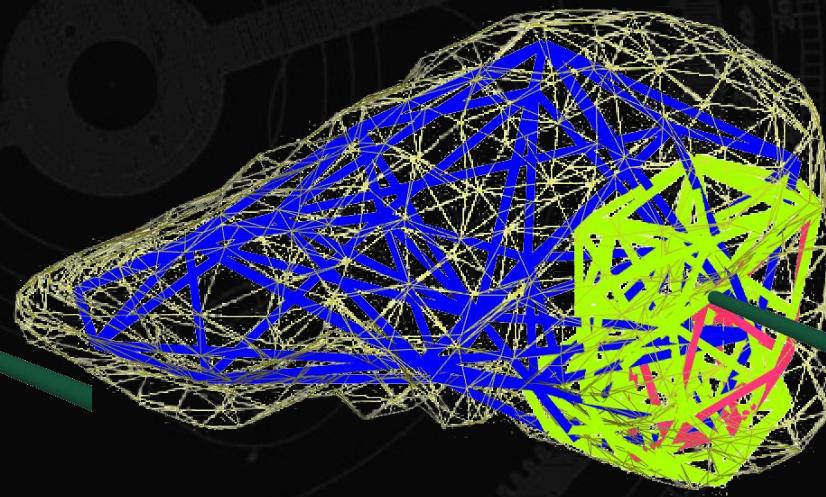
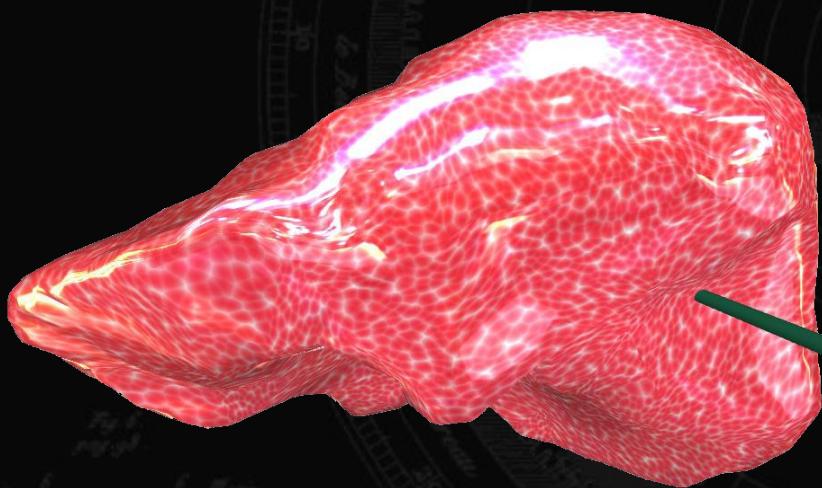
Synchronization with the display

$$dt_i = \frac{dt_{\text{display}}}{2^i}$$

Overview

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Results



Conclusion

Multiresolution in physically-based animation

Real-time simulation guaranteed

- Force feedback at 1000 Hz
- Display at 30 Hz
- Multiresolution speedup factor :
5 - 20

SIGGRAPH

2001

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